§6. Evaluation of Mirror Array Including Phase Correcting Mirrors for a Gyrotron

Idei, H., Notake, T. (Nagoya Univ.),
Shimozuma, T., Ito, S., Kubo, S., Sato, M., Ohkubo, K.,
Shapiro, M., Temkin, R.J. (MIT)

In the 84GHz CPI gyrotron of the $TE_{15,3}$ oscillating mode with a single-stage depressed collecto, a geometric optics Vlasov converter was installed in the tube to convert into a Gaussian beam output. The power flux density transmitted through the gyrotron windows should be generally reduced by flattening the output profile for a longer pulse operation. The output pattern from the gyrotron was flatter than that of the Gaussian beam, and was complicated due to the diffraction at the converter. Although the quasi-optical mirrors based on a Gaussian optics were used to couple the output beam into corrugated waveguides, the coupling efficiency is not so high. The mirror array including the phase correcting mirrors was designed by MIT[1)], shown in Fig.1 schematically. Mirrors 1 and 2 are the phase-correcting mirrors which convert the complicated output pattern from the gyrotron into a elliptical Gaussian beam. The two phase-correcting mirrors were designed, based on the phase distribution retrieved with the MIT code. Mirrors 3 and 4 are quasi-optical mirrors to modify the elliptical Gaussian beam into the HE_{11} mode in the corrugated waveguide. In the low power test, a reciprocal injecting method is adopted to check the performance of these phase correcting mirrors. Well-defined Gaussian beam is injected to Mirror 2 from side of the aperture of the waveguide. This test beam should be converted to the complicated pattern beam after reflections at Mirrors 2 and 1.

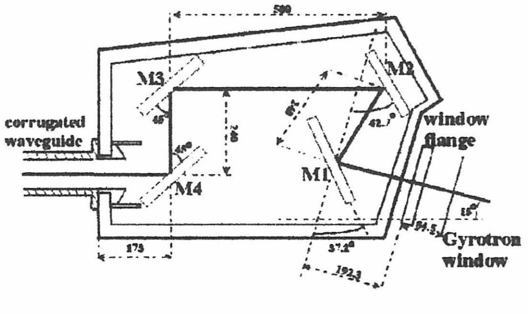

Fig. 1: Mirror array schematic designed by MIT

A low power test stand composed of a vector network analyzer was set up in a frequency range of 40-180GHz[2)]. Using this new system, not only the intensity but also the phase can be measured for the development of the components. The Gaussian test beam to evaluate the mirror array was prepared. Beam sizes $W_{x,y}$ are deduced from the measured intensity profiles in both the x and y directions, as W_x=57mm and W_y=68mm there. Here, the x and y axes are in the plane perpendicular to the propagating z axis. Curvature radii $R_{x,y}$ are also deduced from the measured phase profiles as 1085mm and 940mm. This Gaussian test beam that is described above is injected to Mirror 2. In the MIT calculation, the waist sizes W_x and W_y are 54mm and 70mm, while R_x=1070mm and R_y=930mm, at Mirror 2. The beam parameters for the test beam are similar to those in the calculation. In the MIT calculation, the tilt angles in the x and y directions are 0.2 degree and 1.4 degree, respectively. Beam centers may also be deduced from the intensity profiles. The center positions in the x and y directions are 2mm and 14mm at Mirror 2 in the test, while those are 1mm and 14mm in the calculation, respectively.

The intensity and phase profiles are measured at z=3cm from the gyrotron window after reflections at Mirrors 2 and 1. The beam sizes in the intensity pattern in the test agrees with the calculation. The measured phase distribution indicates that the beam is expanding as designed. The profiles in the x direction at a cut line of y=1.5cm are shown in Figs.2. The cut line crosses near the center of the intensity and phase patterns. Here, the measured central intensity and phase are normalized with those in the calculation. The measured intensity, in particular, phase distributions are similar to those in the calculation. It is indicated that the mirror array designed at MIT using the retrieved phase distribution work well.

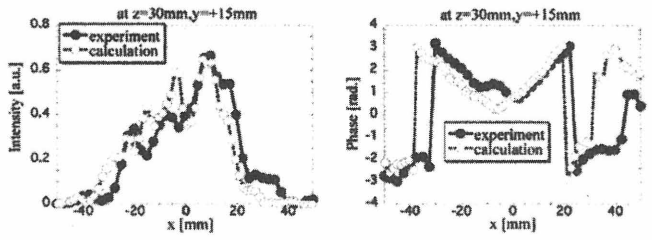

Fig. 2: Measured and calculated profiles : (a)Intensity and (b)Phase profiles in the x direction at z=3cm from the gyrotron window with a cut line of y=1.5cm.

Reference

1) Shapiro, M.A., *et al.*, Fusion Eng. Design 53 (2001) 537.
2) Idei, H., *et al.* Proc. of 26th Int. Conf. on IRMMW (2001).